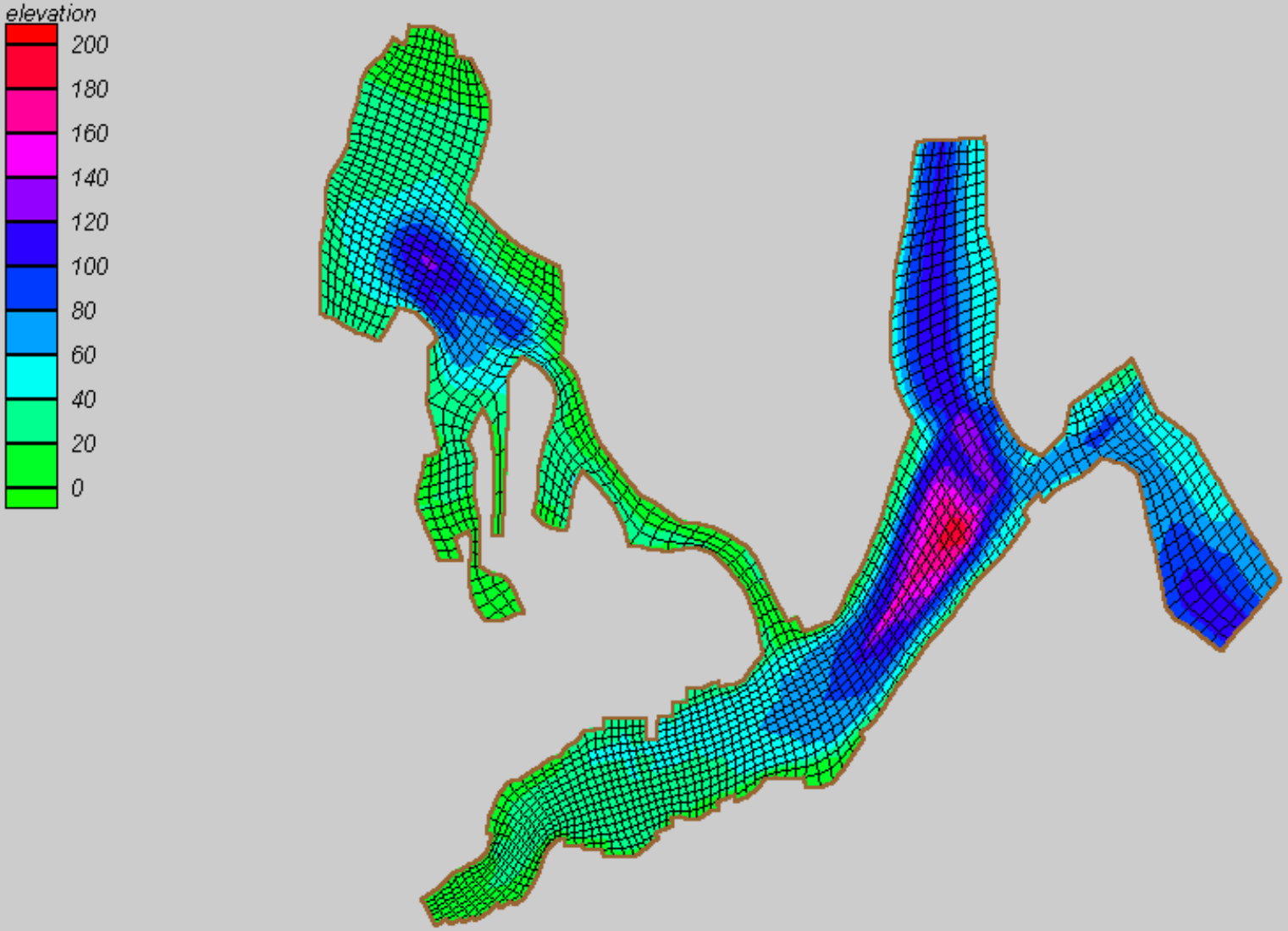
Dispersion of Fecal Coliform From CSO Discharges in Dyes Inlet

A Joint Effort
by
DOH of the Washington State
Suquamish Tribe
City of Bremerton
Kitsap County
PSNS
CTC
SSC

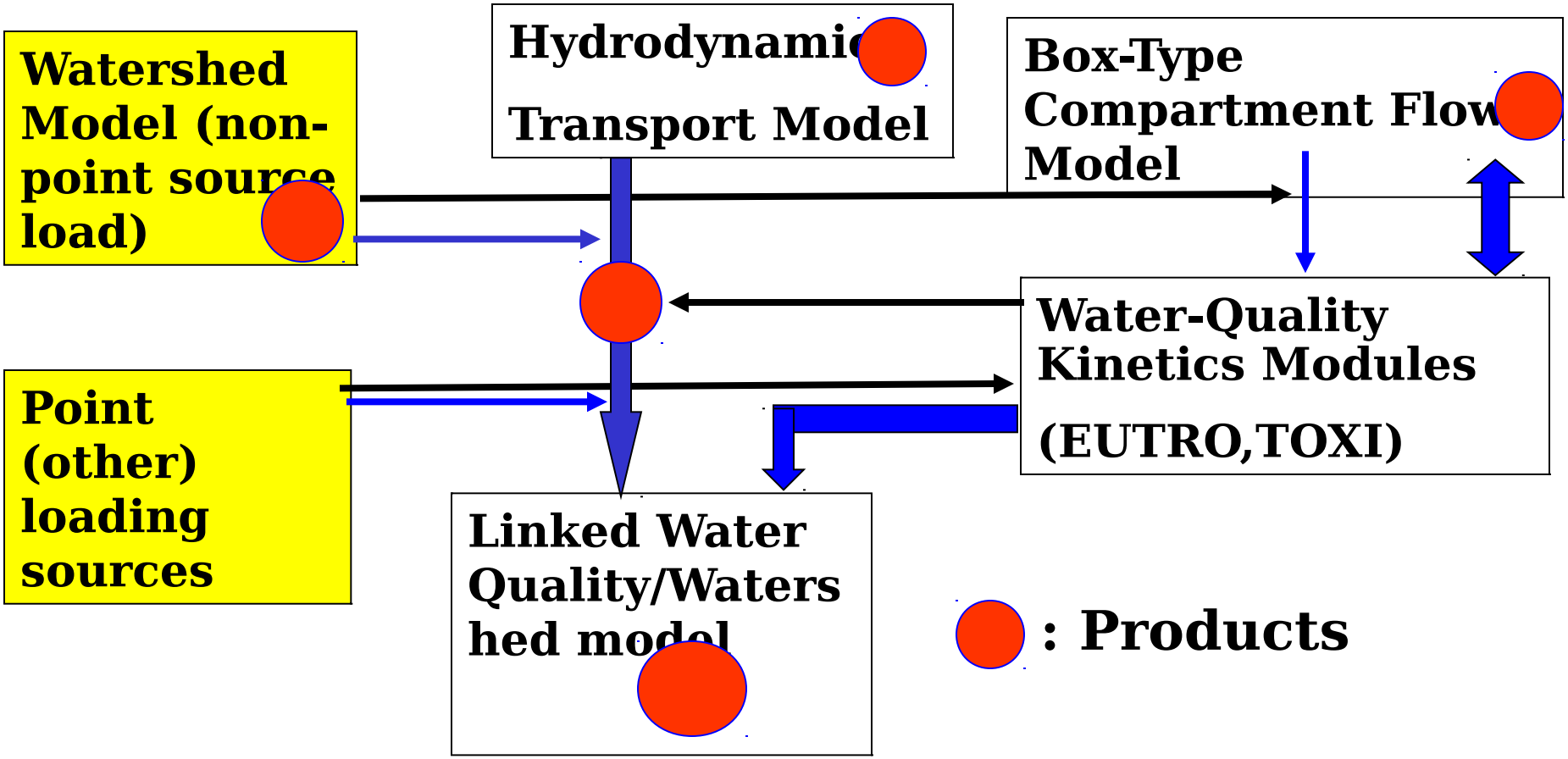
Refined CH3D-Grid for CSO Dispersion in Dyes Inlet



Integrated Water-Quality-Watershed Models for Sinclair Inlet

- **Processes:**
  - **Physical: advection, dispersion, dilution, flushing, wind-driven currents**
  - **Biological/Chemical: nitrification, mineralization, nutrient-uptake, algae growth**
  - **Scales: spatial and temporal**
  - **Models: watershed, hydrodynamics, water quality**

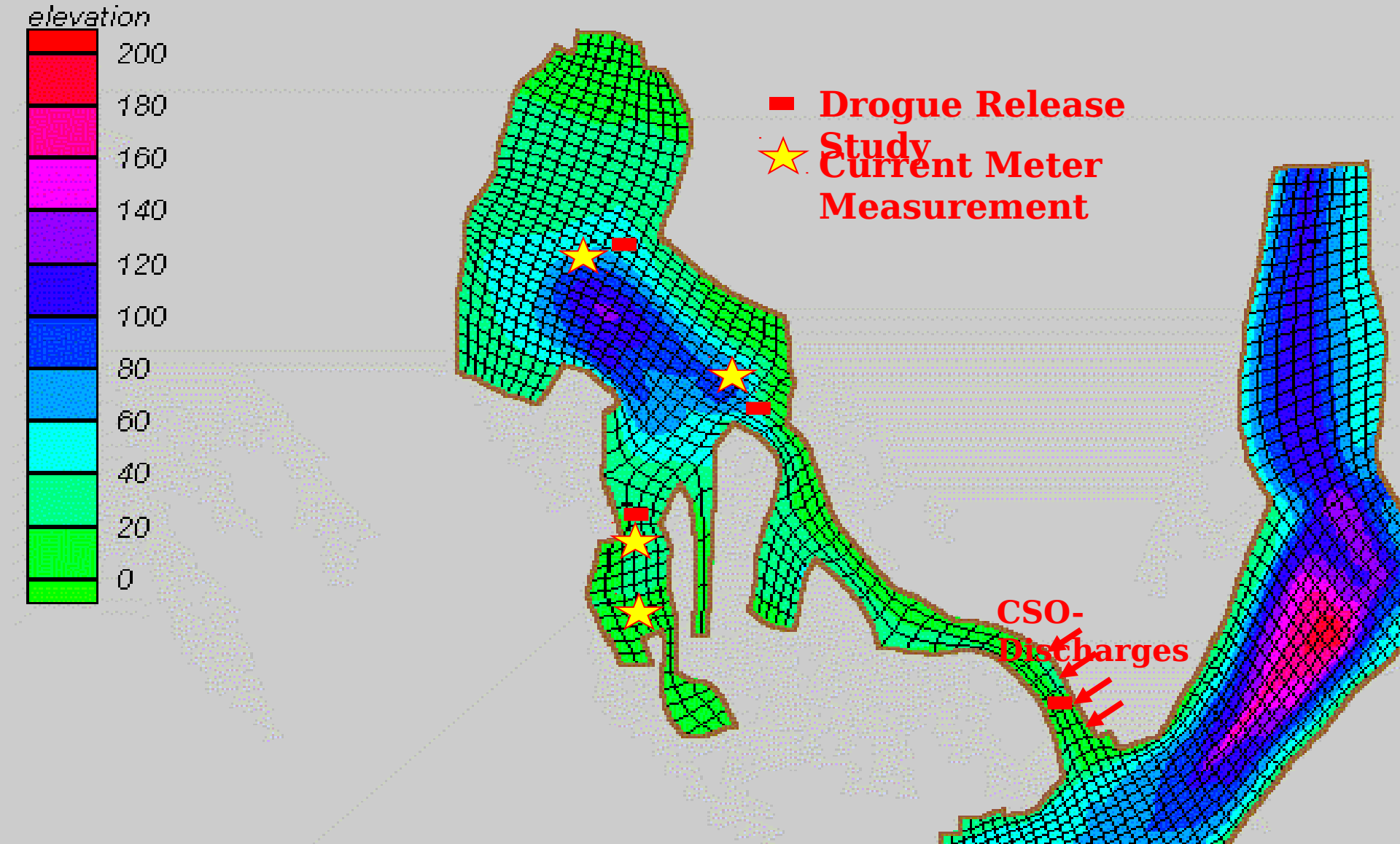
Sinclair Inlet TMDL Modeling



Modeling Status Summary- CH3D-Drogue Study

- 4 drogue releases and data recovered
- A refined CH3D grid is generated
- A Lagrangian transport module is added into CH3D for drogue trajectory
- Completed preliminary model-data comparisons
- Fecal Coliforms death rate on salinity/temperature /light is being added into the model

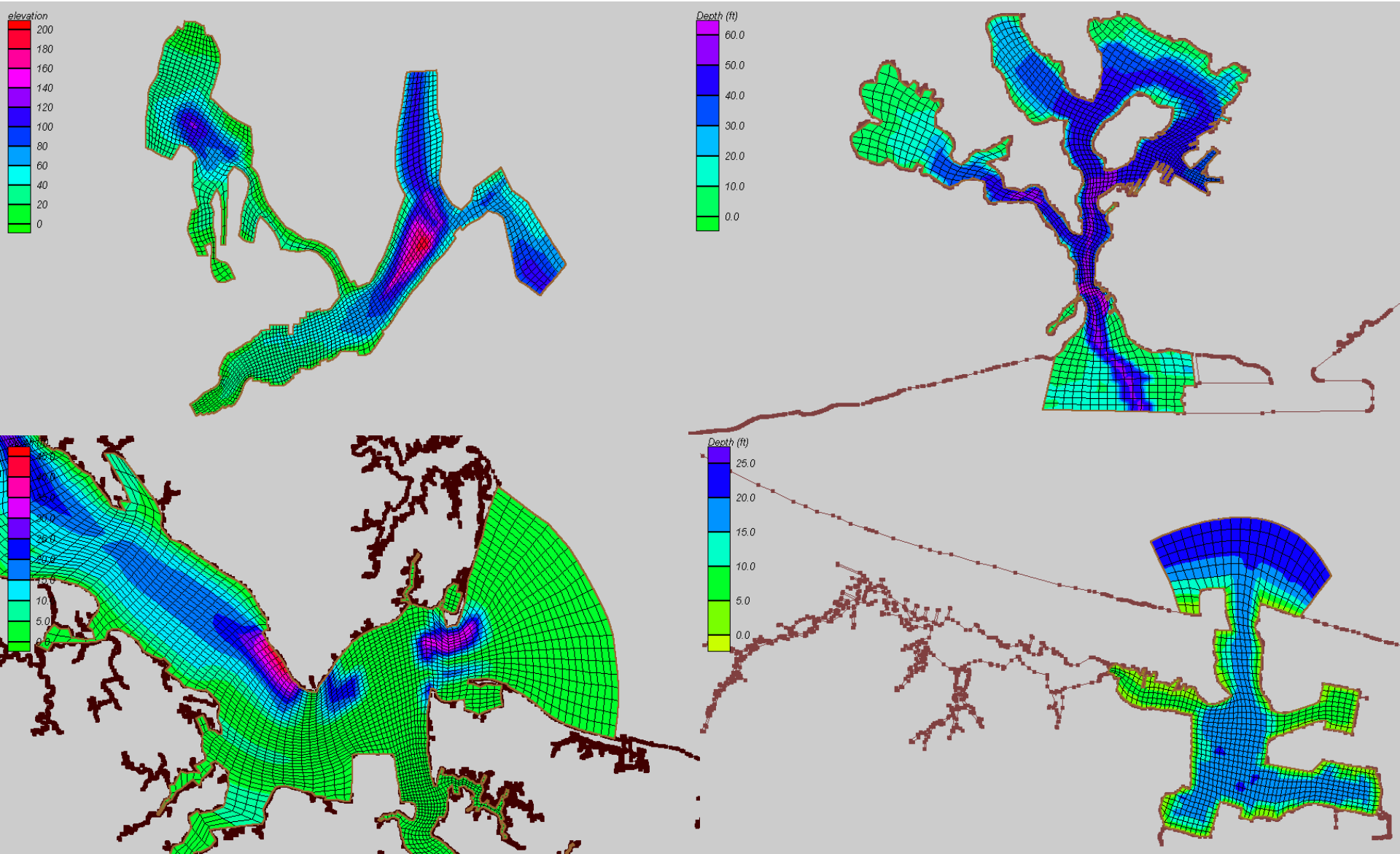
Refined Grid for CSO Dispersion in Dyes Inlet



NUMERICAL HYDRODYNAMIC MODEL:CH3D

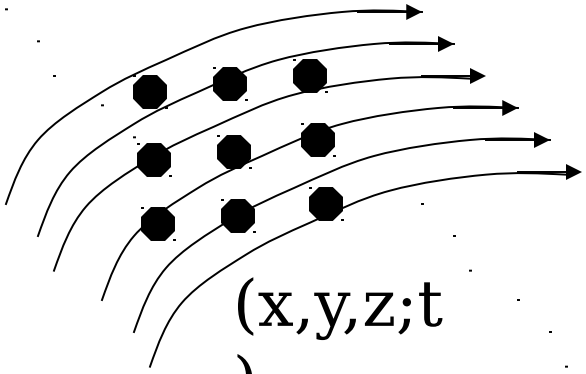
- Three-dimensional free surface, hydrodynamic model (Johnson et al, 1990; Wang and Chapman, 1995)
- Non-orthogonal, boundary fitted coordinates
- finite difference scheme
- Initial and boundary condition
- Processes affecting circulation
  - Tides
  - river inflow and density effects (salinity, temperature)
  - Wind /Barometric pressure
  - Earth’s rotation
  - Turbulence

NUMERICAL HYDRODYNAMIC MODEL:CH3D



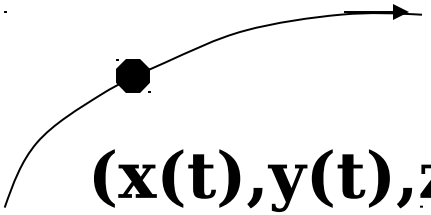
Lagrangian Drogue Trajectory Study

- **Eulerian**: time series data at **fixed** locations



U(x,y,z;t)

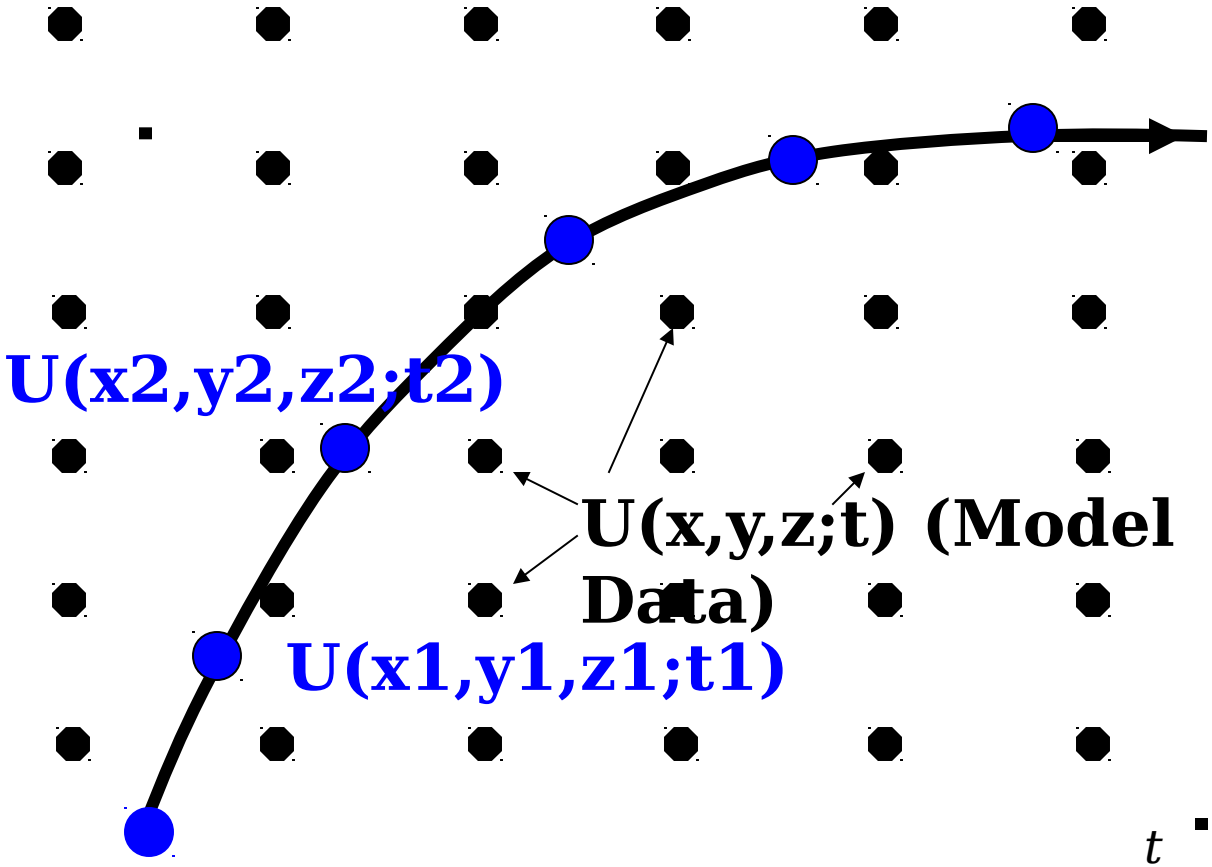
- **Lagrangian**: time series data of the object which is moving along with flow



(x(t),y(t),z(t);t)

U(x(t),y(t),z(t);t)

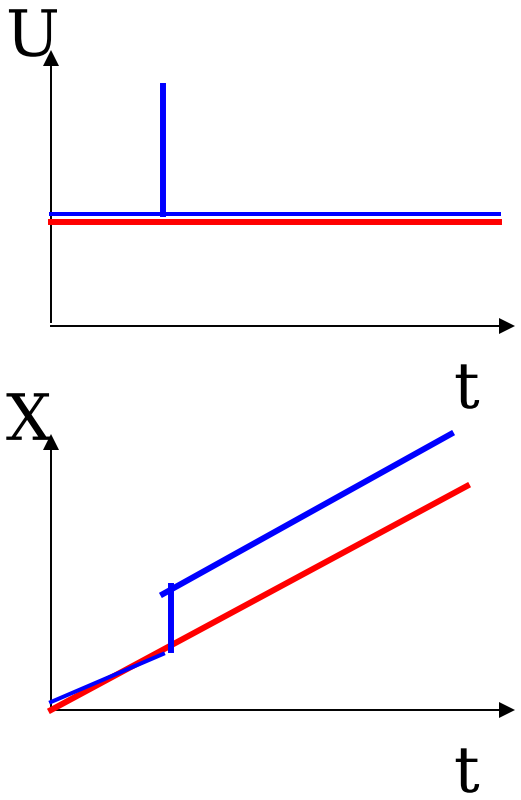
Lagrangian Drogue Trajectory Study

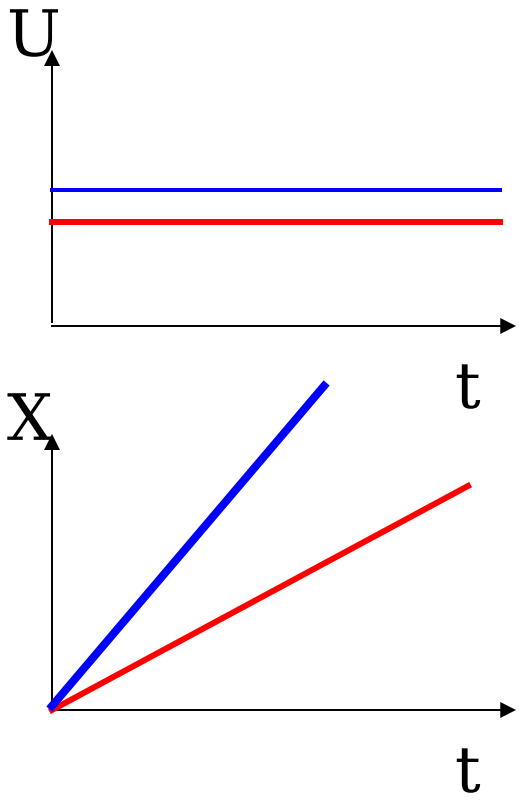


$$X(x,y,z;t) = \int_{t=t0}^{t} u(x,y,z;t')dt'$$

Lagrangian Drogue Trajectory Study

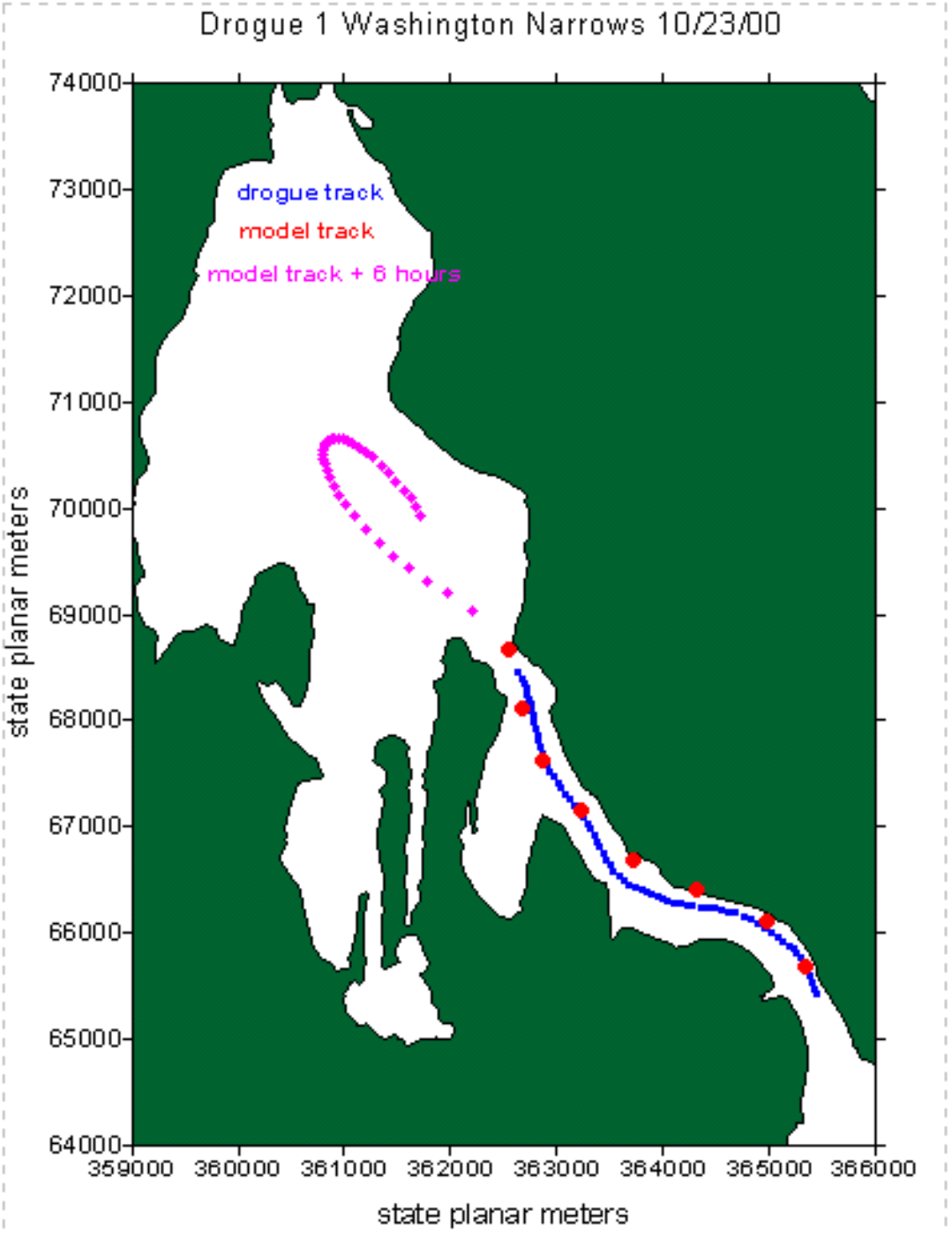
- **Error Sources from model:**
  - **Interpolation from Eulerian model results**
  - **Errors accumulate over time**





Lagrangian Drogue Trajectory Study

- **Discrepancy Sources:**
  - **Wind Effect**
    - **Wind force**
    - **Wind-induced currents**
    - **Wind-induced waves**
  - **Large-Body Effects:**
    - **Inertia**
    - **Friction**
    - **Turbulence**
- Drogue trajectories compared with model results for general flow characteristics (Blumberg et al., 1999, JHE, ASCE, Grace, 2000, JHE, ASCE)


Drogue 1 Washington Narrows 10/23/00
drogue track
model track
model track + 6 hours
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state planar meters
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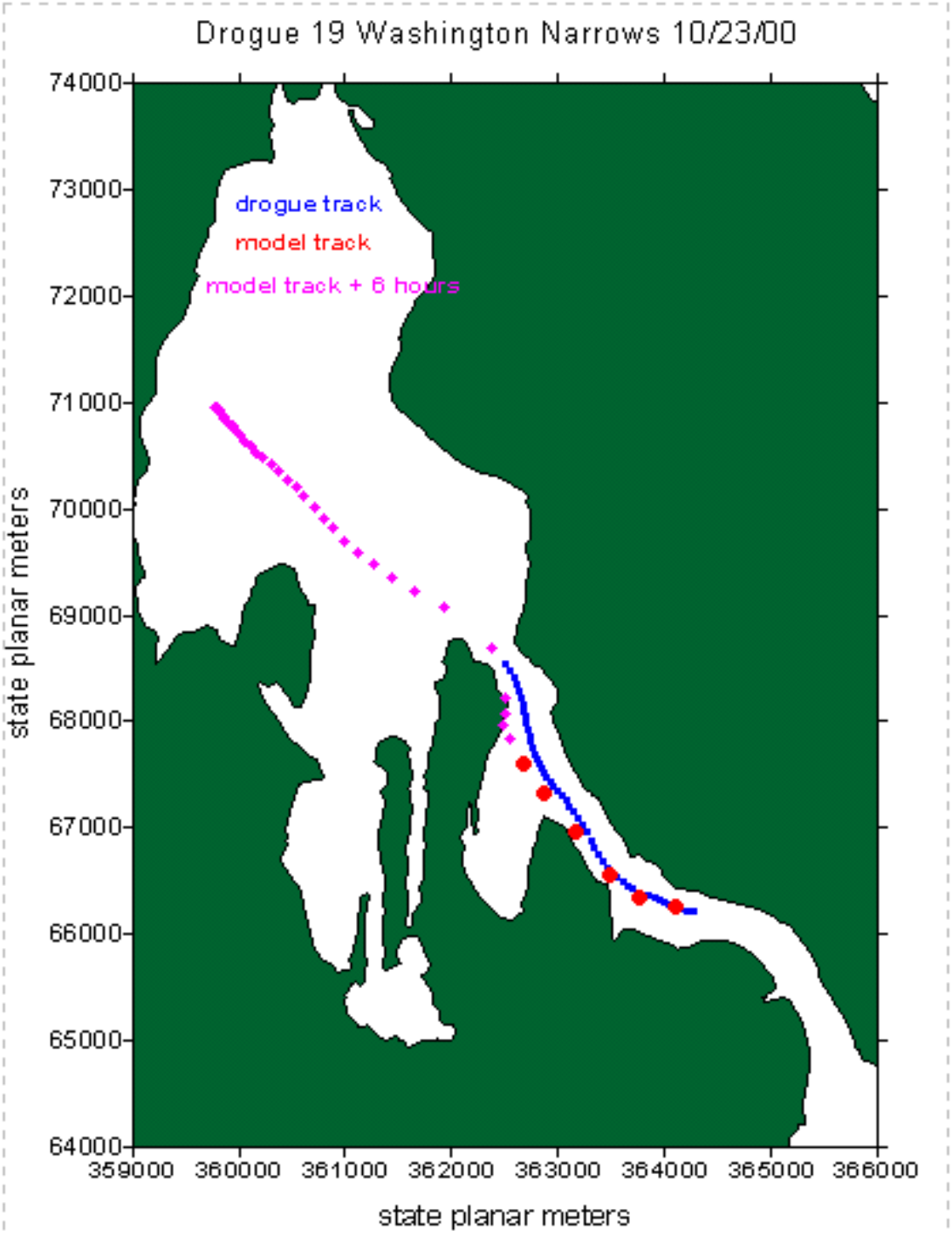
Drogue 19 Washington Narrows 10/23/00
drogue track
model track
model track + 6 hours
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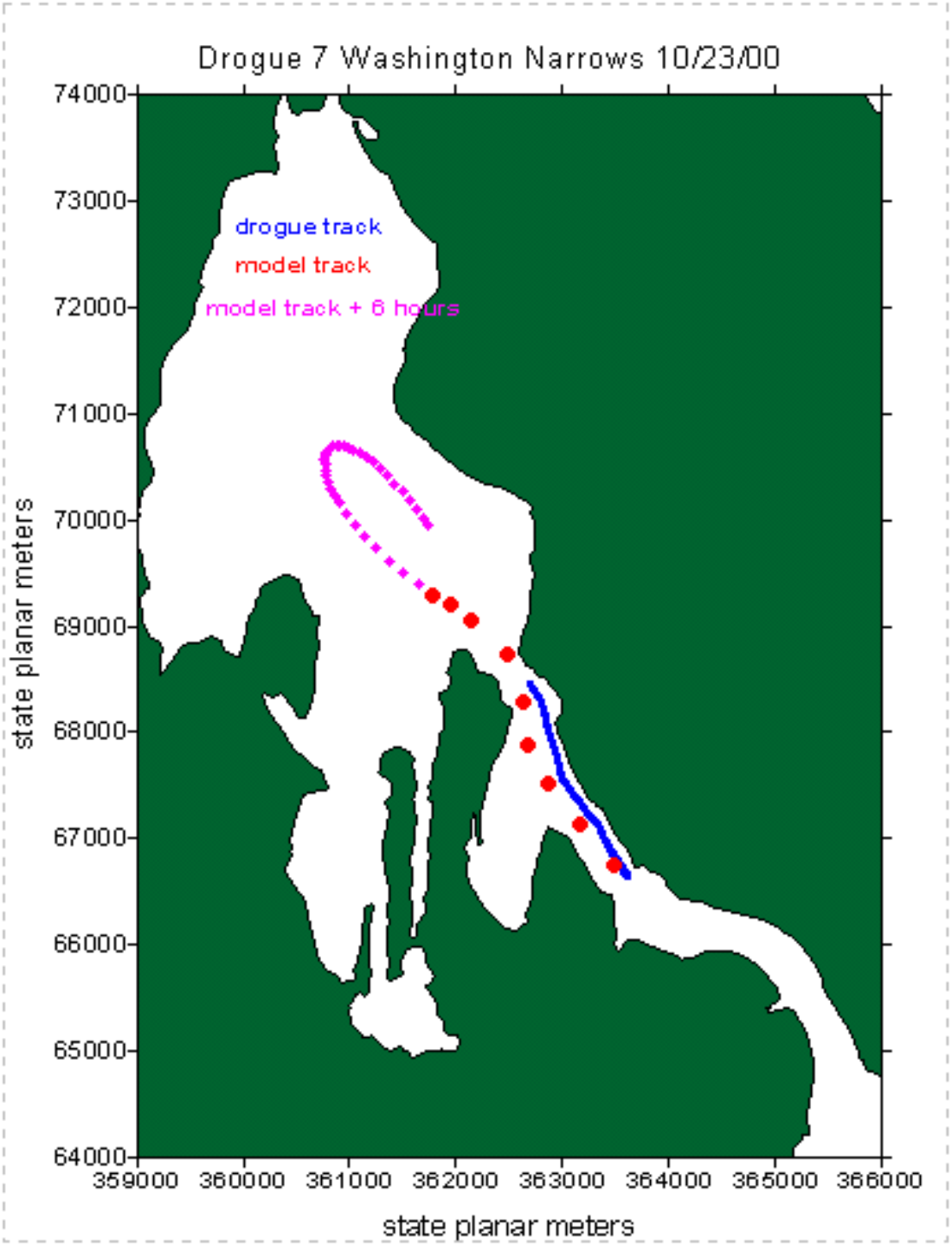
Drogue 7 Washington Narrows 10/23/00
drogue track
model track
model track + 6 hours
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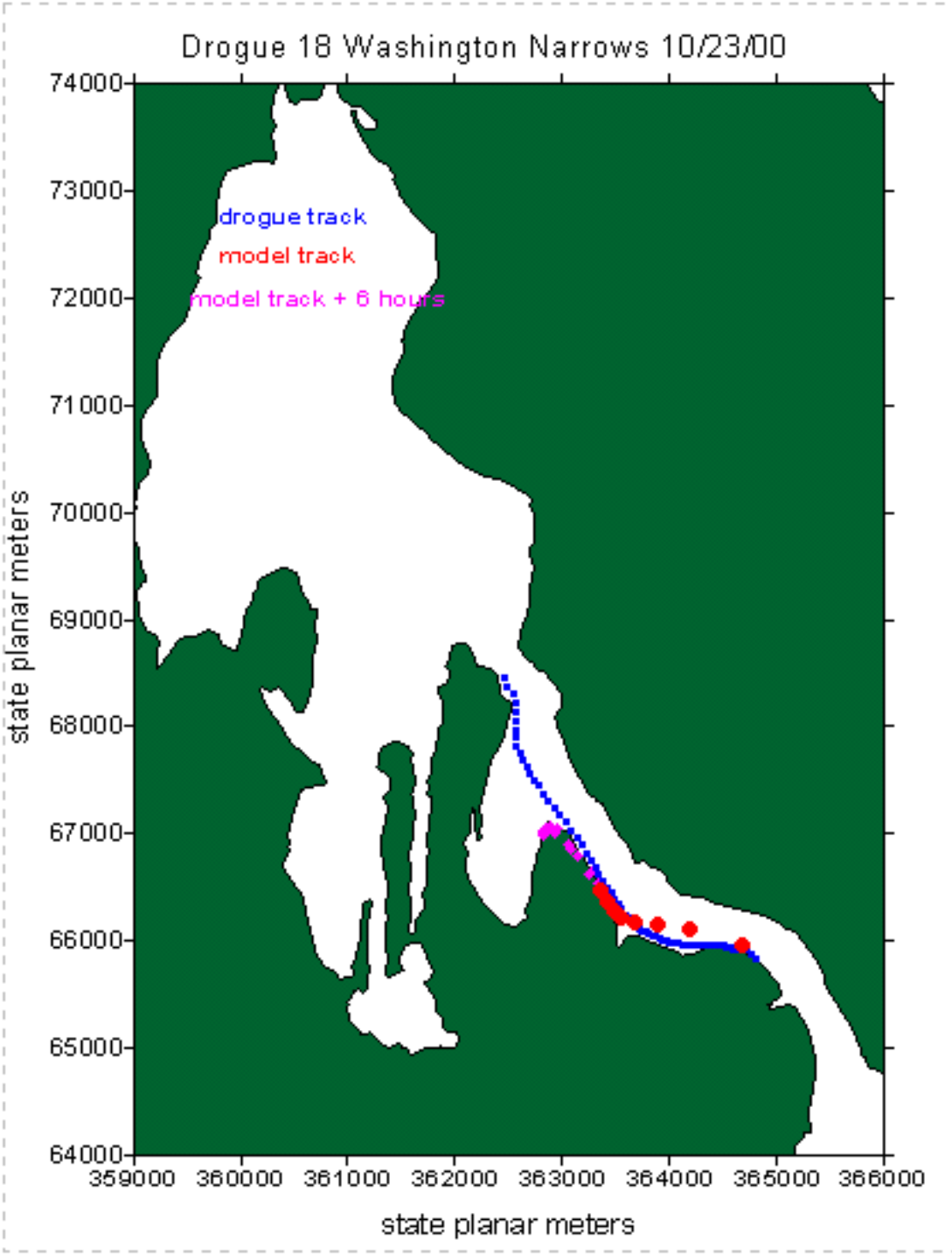
Drogue 18 Washington Narrows 10/23/00
drogue track
model track
model track + 6 hours
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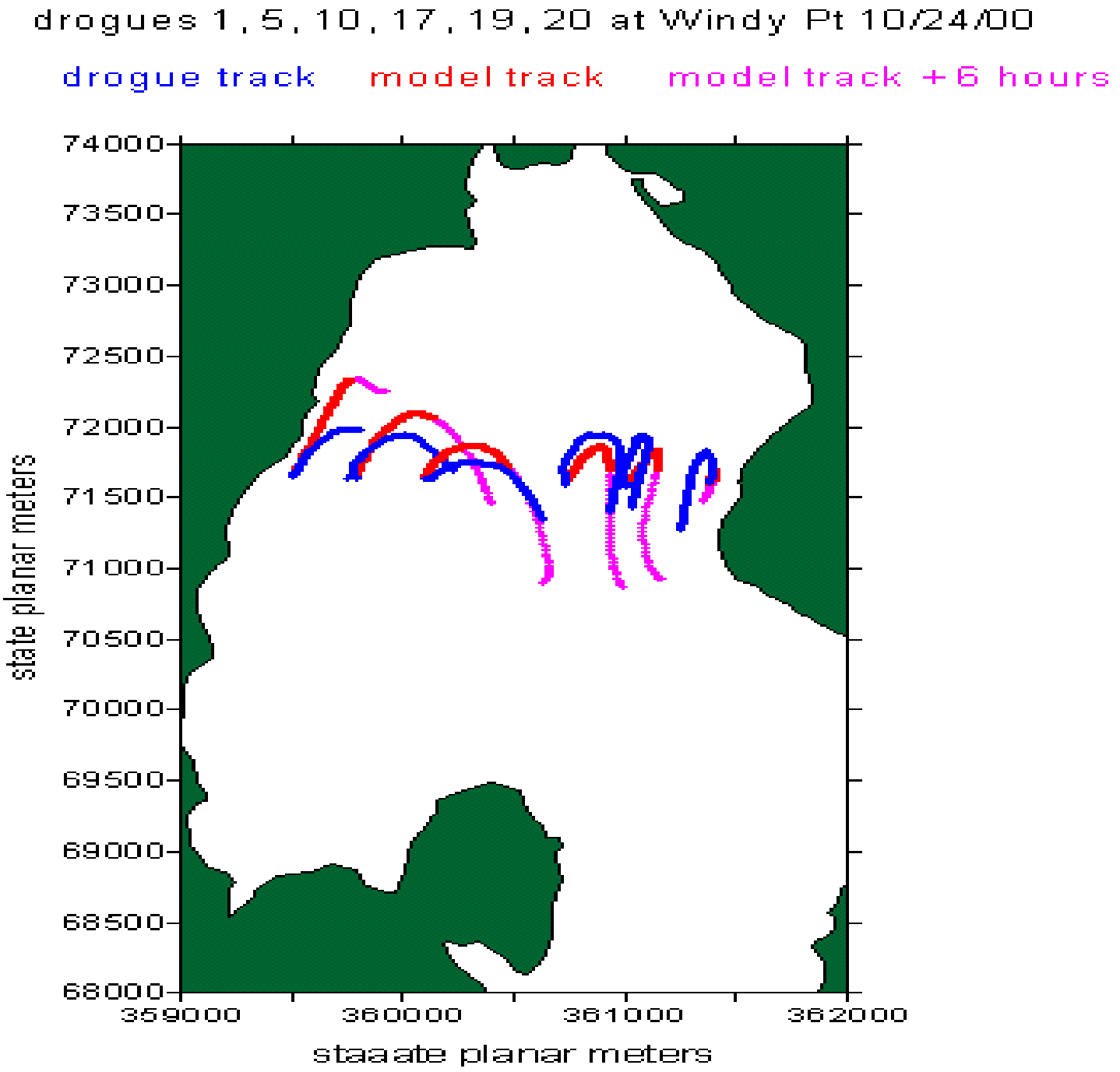
drogues 1, 5, 10, 17, 19, 20 at Windy Pt 10/24/00
drogue track
model track
model track +6 hours
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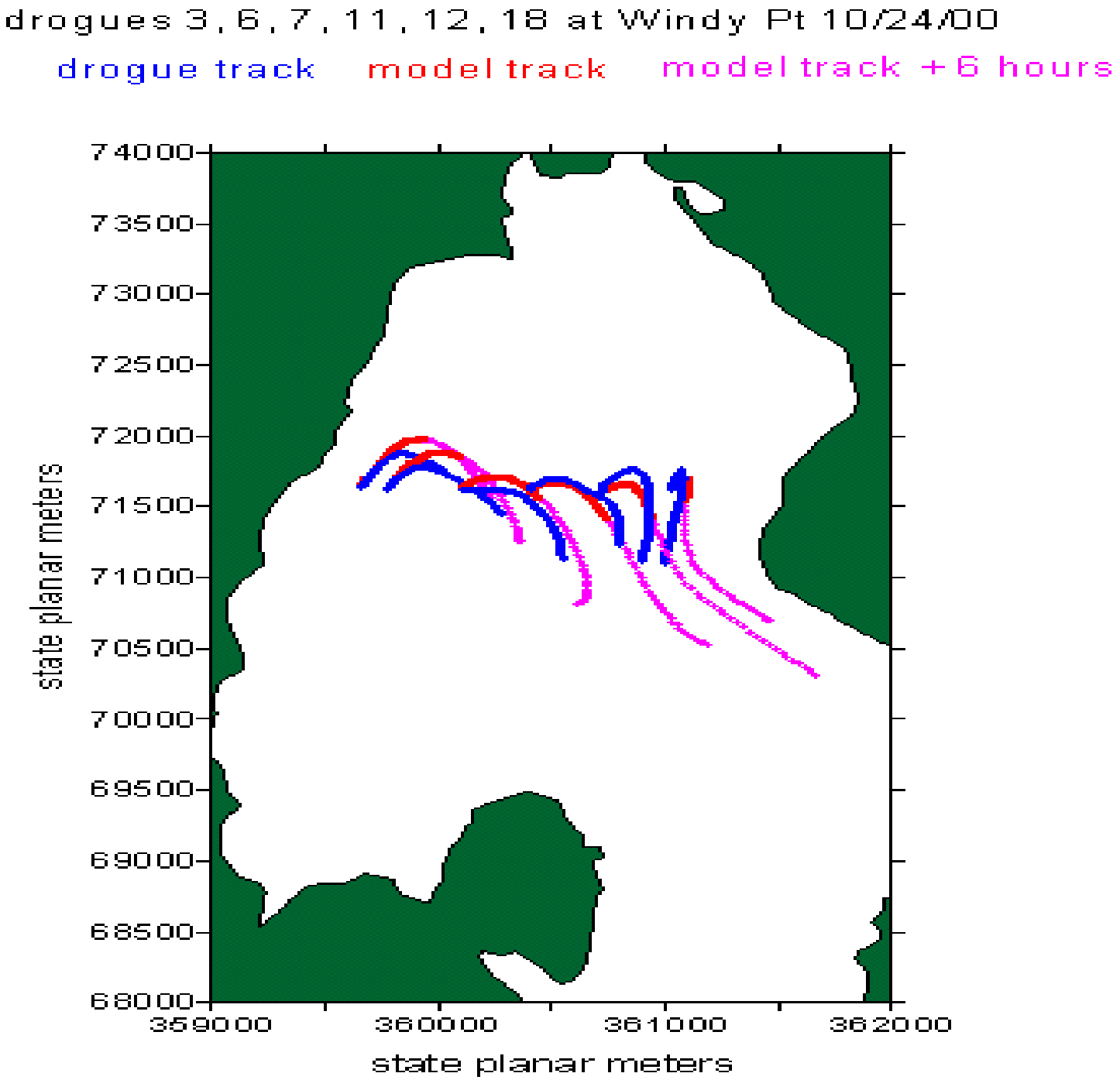
drogues 3, 6, 7, 11, 12, 18 at Windy Pt 10/24/00
drogue track
model track
model track +6 hours
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69500
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68500
68000
state planar meters
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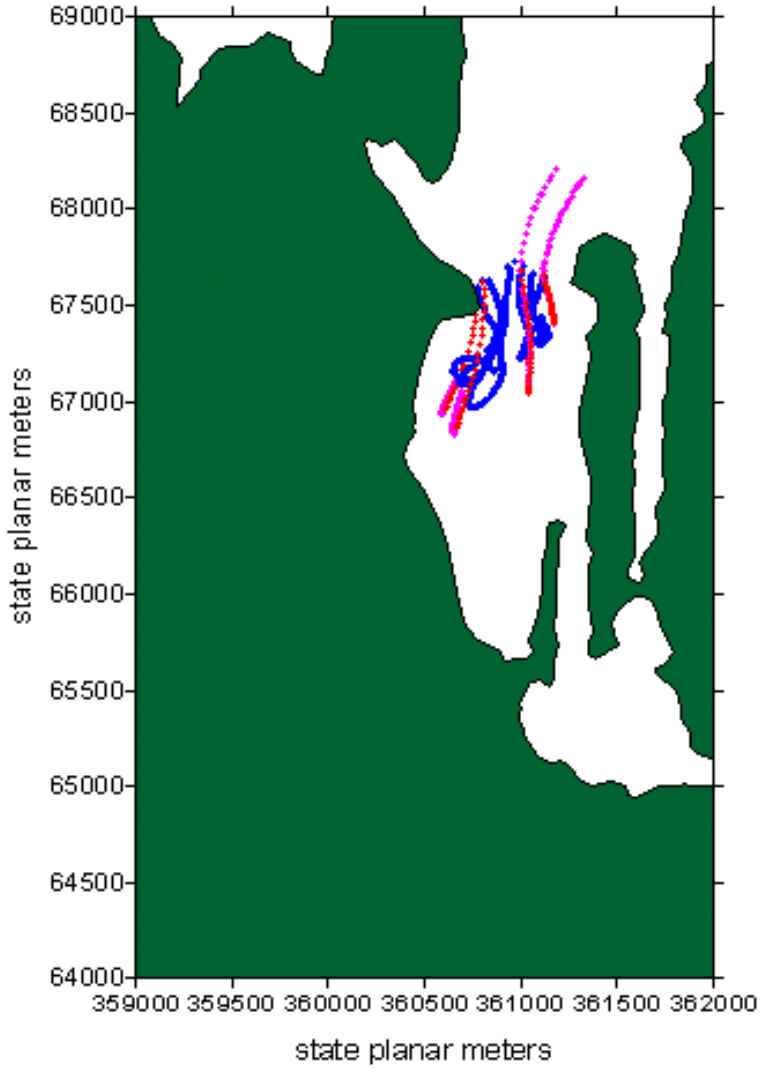
state planar meters

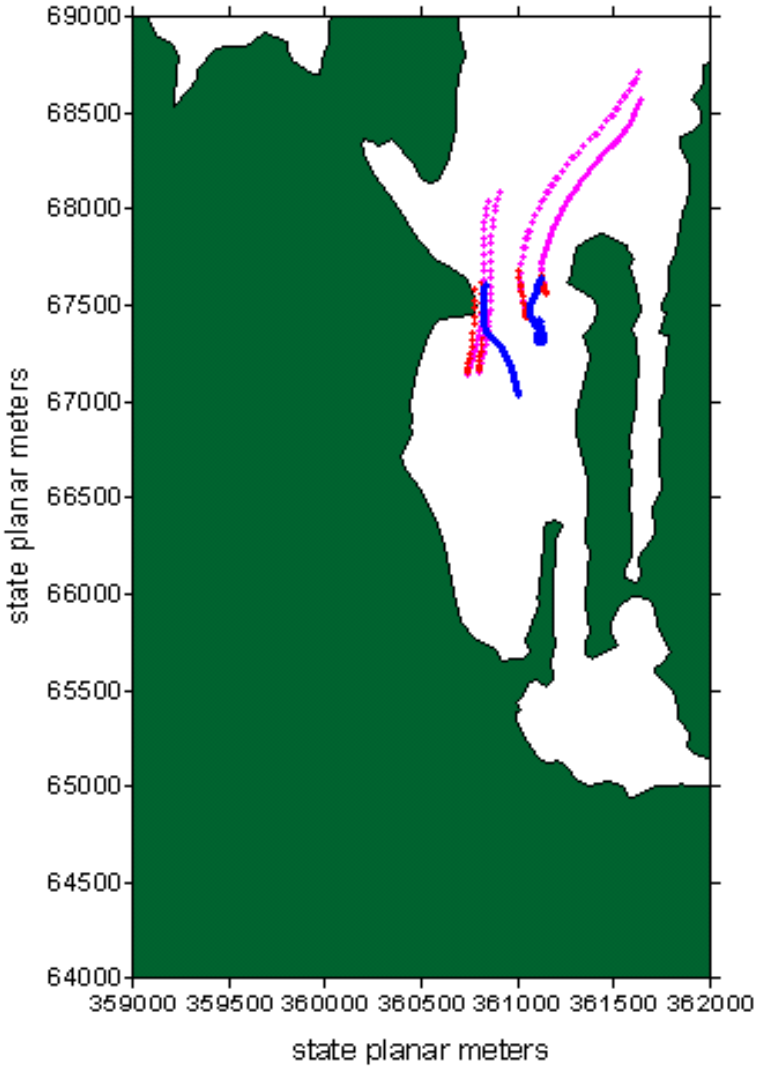
drogues 2, 13, 14, 15, 16, and 19 in Ostrich Bay 10/13/00

drogue track model track model track +6 hours



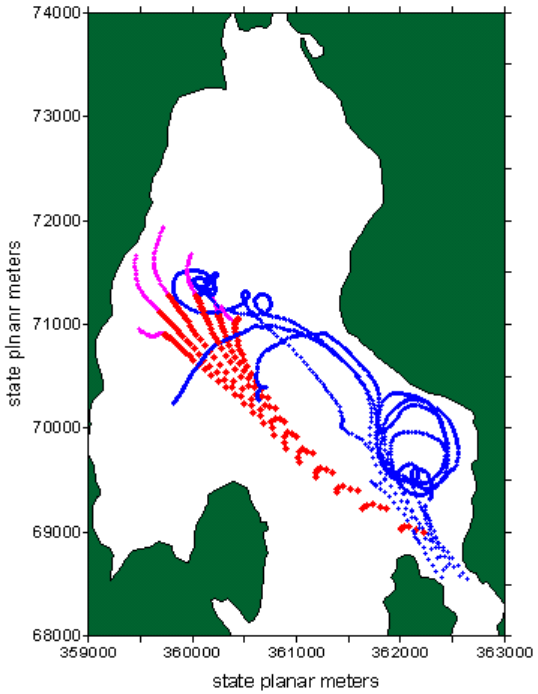
drogues 3, 7, 8, 9, 10, and 11 in Ostrich Bay 10/13/00

drogue track model track model track +6 hours



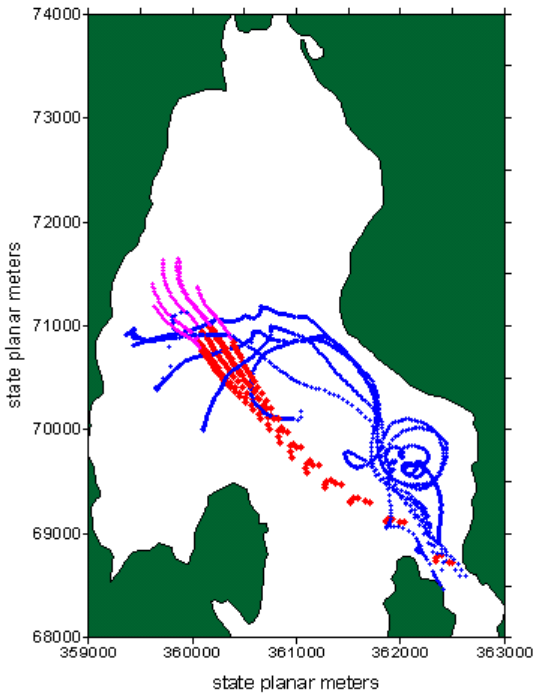
drogues 1, 2, 12, 13, 15, 17 at Rocky Pt 10/20/00

drogue track model track model track +6 hours



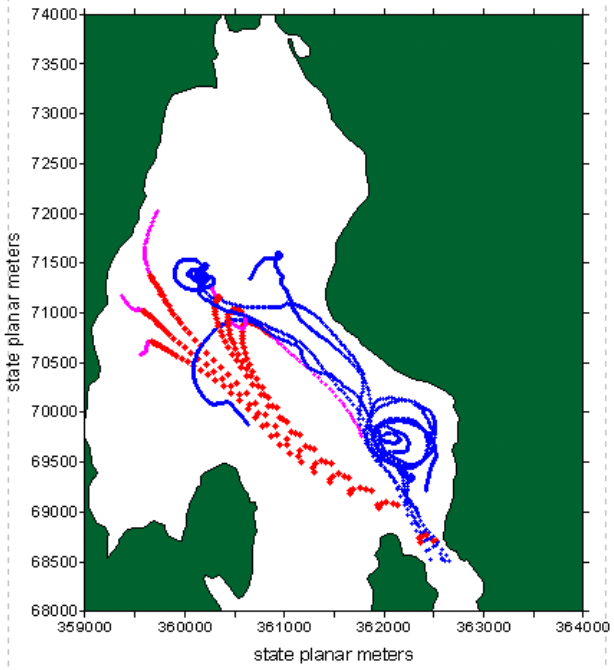
drogues 3, 6, 8, 9, 16, 20 at Rocky Pt 10/20/00

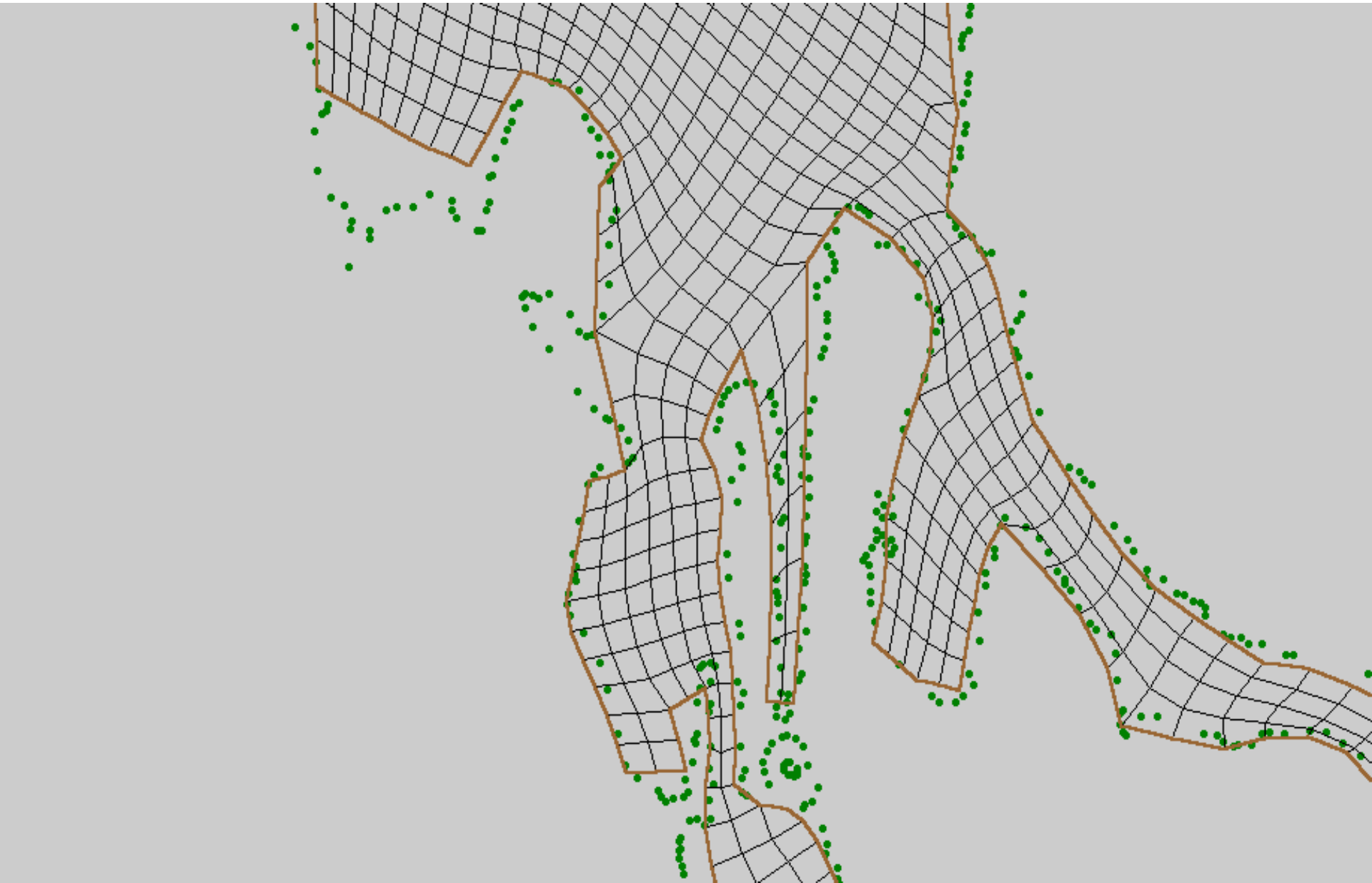
drogue track model track model track +6 hours



drogues 4, 7, 10, 14, 18, 19 at Rocky Pt 10/20/00

drogue track model track model track +6 hours



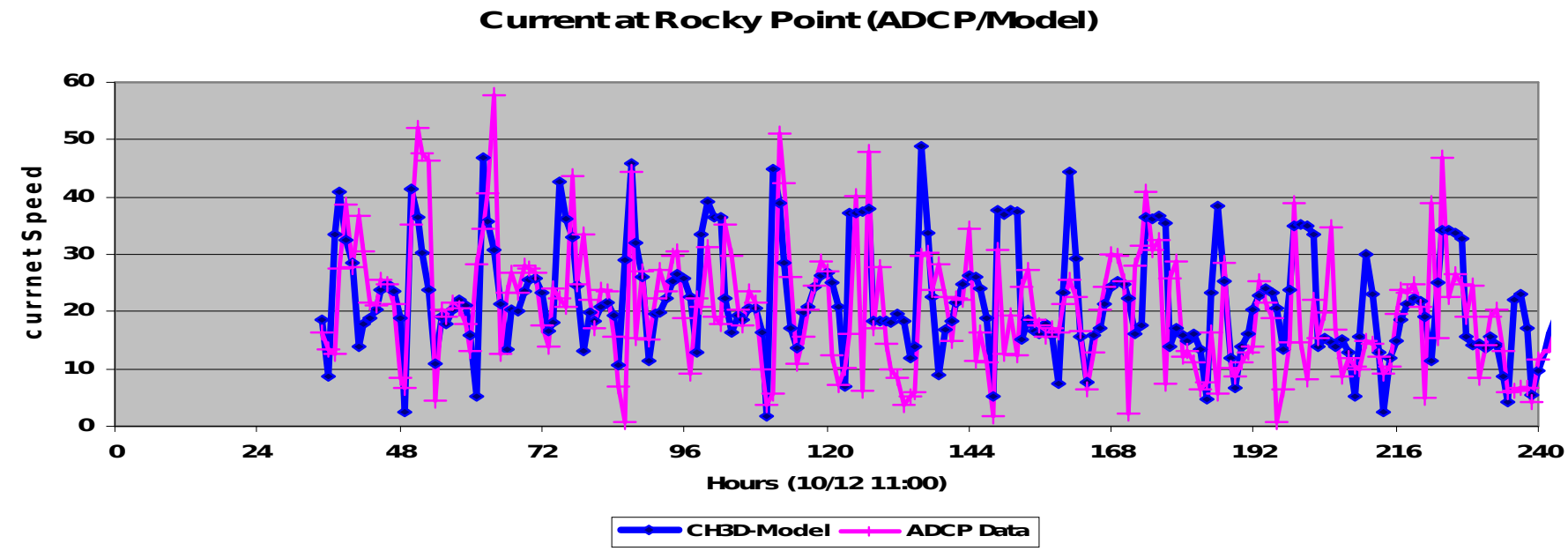


Summary and Work to be done

- **Continue to refine and enhance CH3D-FC model, with more data are becoming available**
- **Add in the specific empirical formula that DOH provides (K=K(S,T,I))**

$$K = (a + b * S) * c^{(T - 20)} + \frac{I}{kh}(1 - e^{-kh})$$

- **Work with clients to collect/compile/analyze existing data**
- **Design diagnostic model runs**
- **CH3D-FC model test runs, calibration runs**
- **CH3D-FC model verification**
- **Scenario studies**


Current at Rocky Point (ADCP/Model)
currnet Speed
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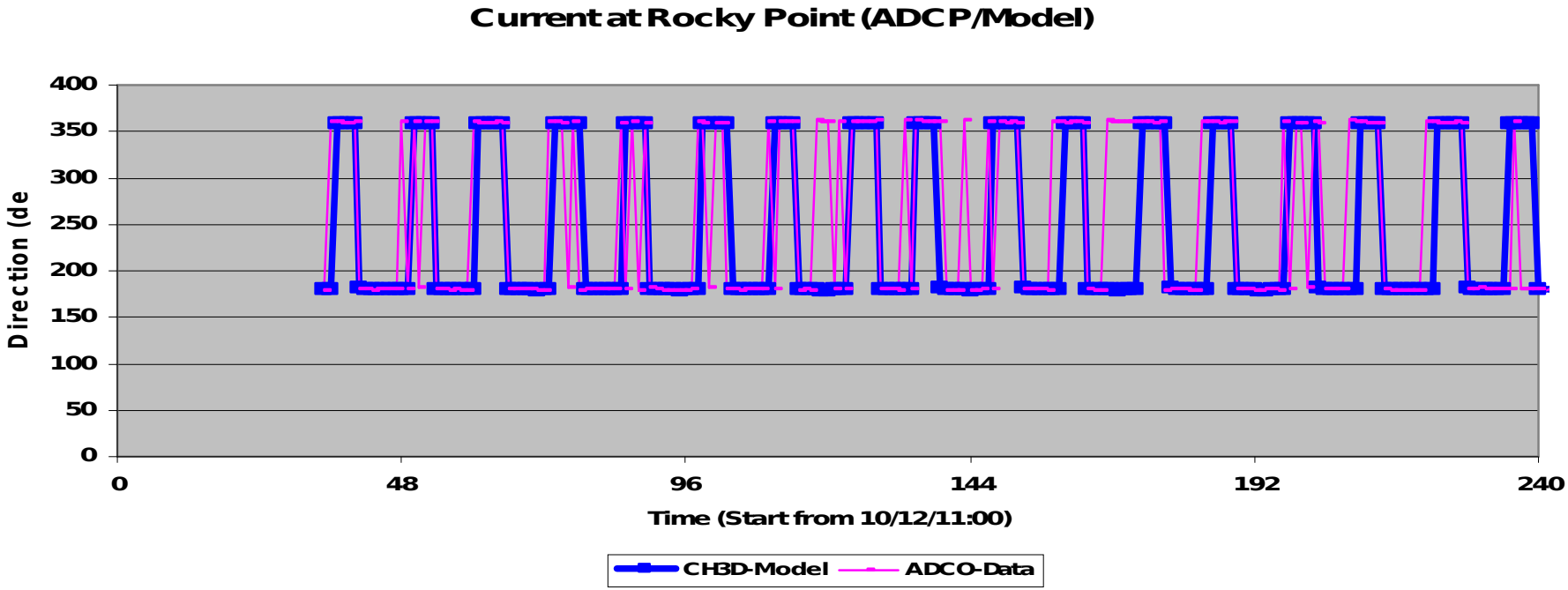
Hours (10/12 11:00)
CH3D-Model
ADCP Data


Current at Rocky Point (ADCP/Model)
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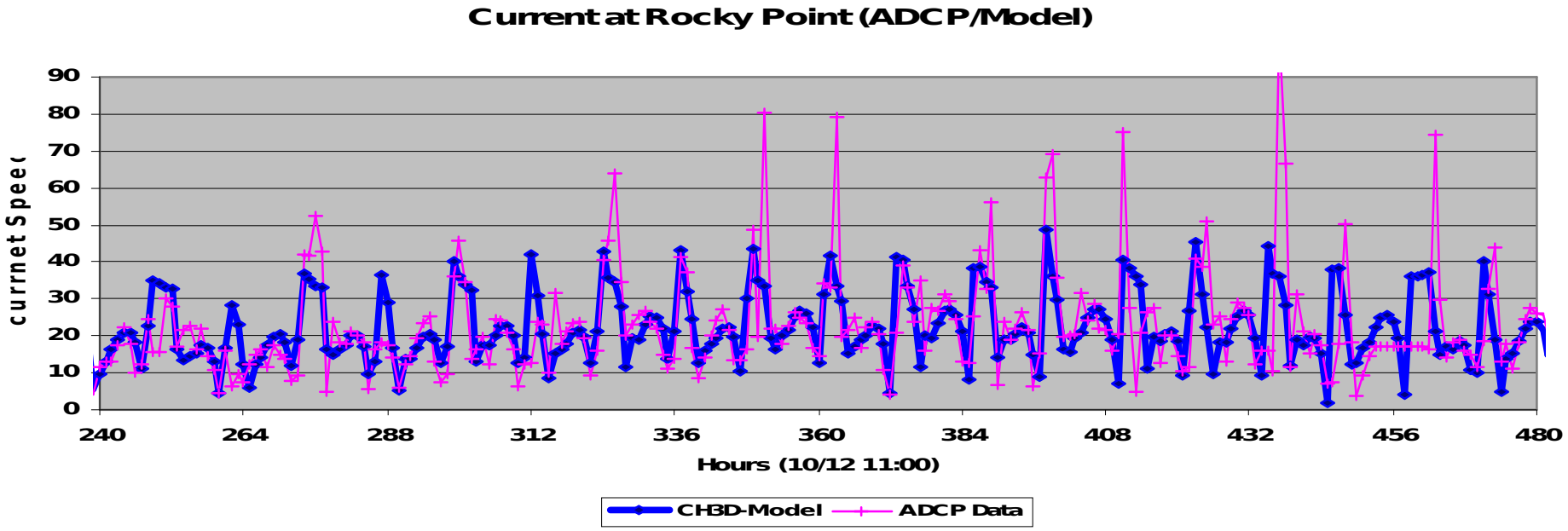
Time (Start from 10/12/11:00)
CH3D-Model
ADCO-Data


Current at Rocky Point (ADCP/Model)
currnet Speed
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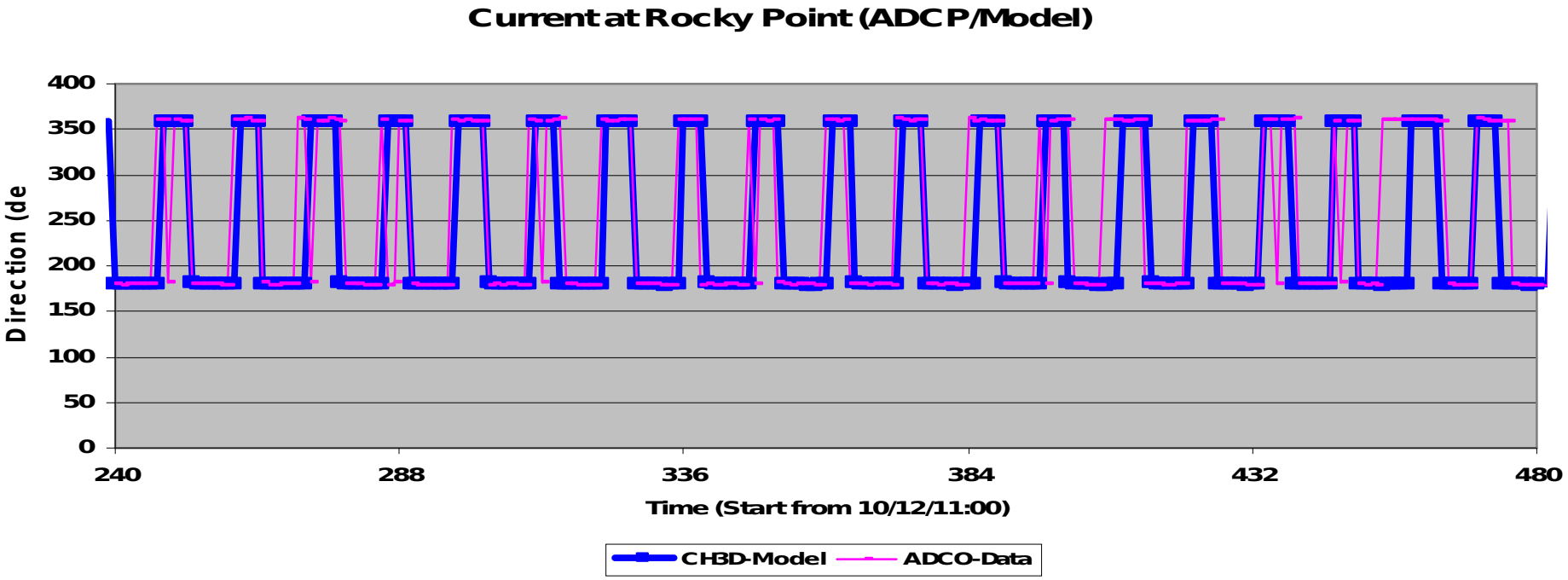
Hours (10/12 11:00)
CH3D-Model
ADCP Data


Current at Rocky Point (ADCP/Model)
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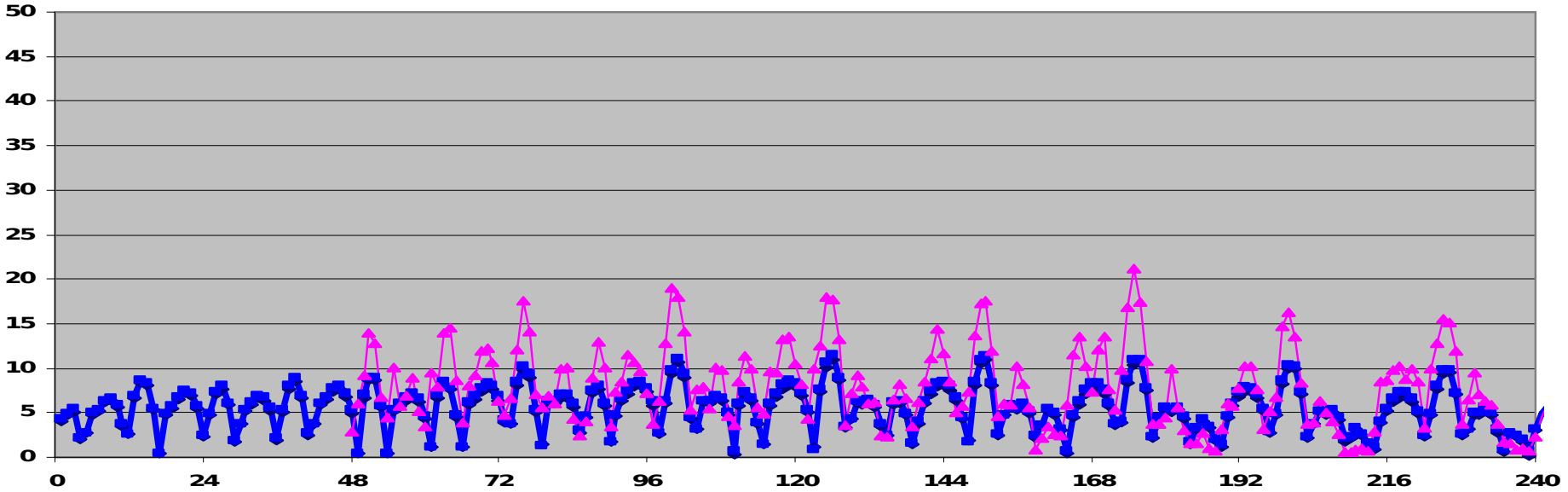
CH3D-Model
ADCO-Data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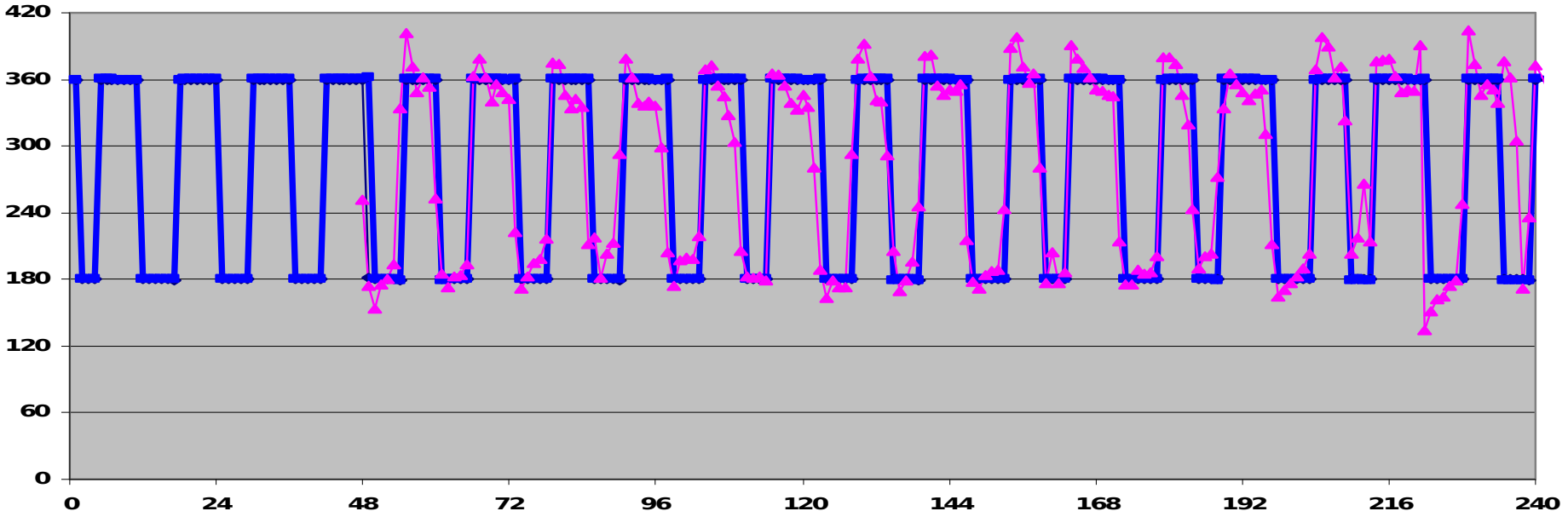
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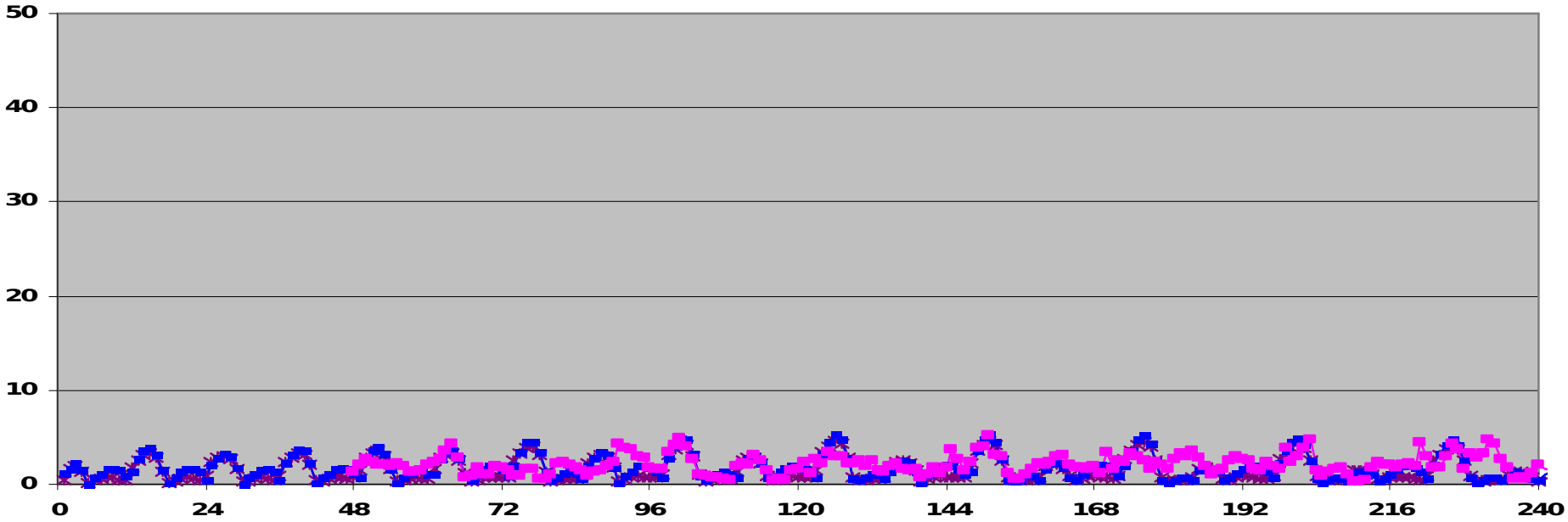
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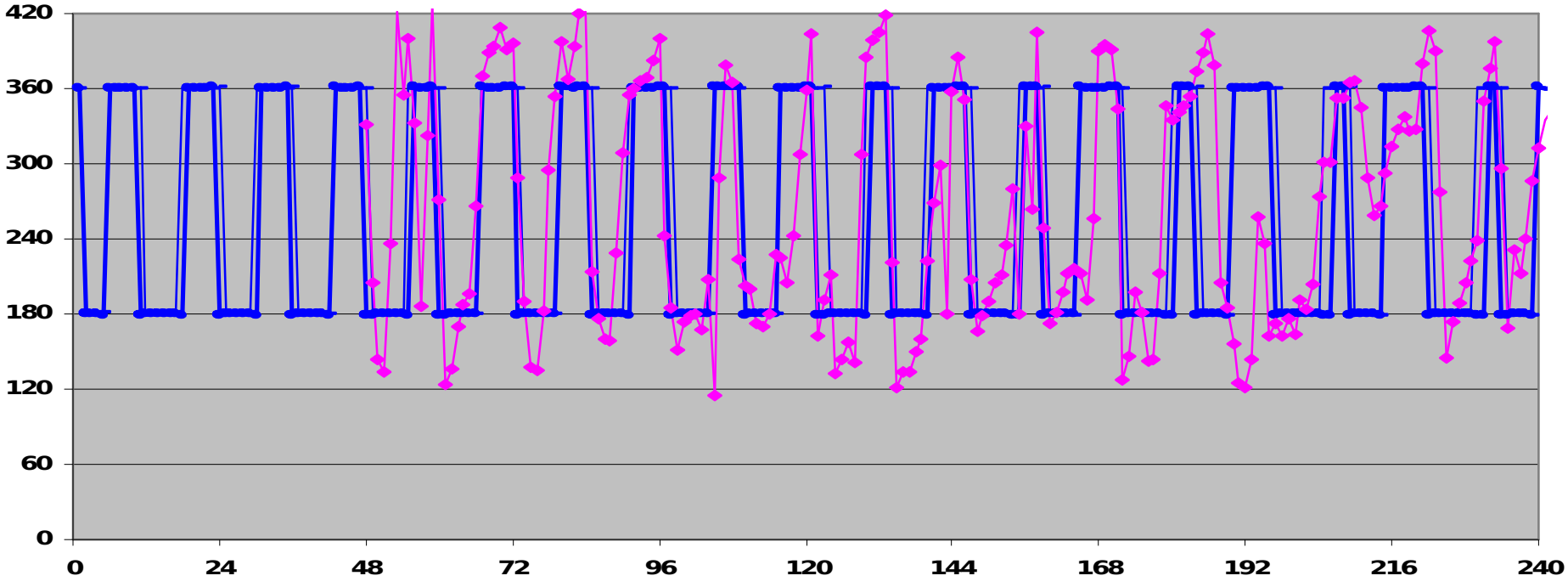
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WASP-Box Model Calibration

$$\frac{\partial C}{\partial t} = \frac{\partial (QC)}{\partial x} + \frac{\partial}{\partial x}\left[D \frac{\partial C}{\partial x} \right] + \oplus$$

Where:

C: concentrations

Q: Freshwater advection

D: Hydrodynamic dispersion

⊕: Source/Sink

WASP-Box Model Calibration

$$\frac{\partial C}{\partial t} = \frac{\partial (QC)}{\partial x} + \frac{\partial}{\partial x}\left[D \frac{\partial C}{\partial x} \right] + 0$$

Steady-State Condition

Conservative: Salin

Where

C: salinity concentration (derived from existing data)

Q: Freshwater inflows (extrapolated from existing data and/or from HSPF)

D: Dispersion coefficient to be solved.

Integrated Water-Quality-Watershed Models for Sinclair Inlet

- Issues
  - Contaminants of Concern
    - Metals (Cu)
    - Eutrophication: Algae Bloom, Low DO, W.Q.
    - Solids
    - PCB
  - TMDL
    - Shipyard and other point discharge sources
    - Watershed runoffs
  - Fecal Coliform (CSO) dispersion

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